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NOTES ON WRITING AND EDITING TECHNICAL PAPERS*

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The introduction to a culinary article carried the significant remark that "the making of mince pies is a serious matter, not to be lightly undertaken." We may not have thought of it as such, but it is another illustration of the fact that most anything that is well done is undertaken in a painstaking manner. This is true, or ought to be, in writing a bulletin or a technical article. It is a serious matter, in that it deserves to be done well, and it is not to be lightly undertaken without time or patience to do a careful, studious job.

Ring Lardner recently referred frivolously to some people who wrote English but couldn't speak it. Conversely, many who speak English fluently have trouble in writing it. And this is easily understood, for of course it is far more difficult and most people have much less practice in writing than in talking. Spoken errors do not stand out as written ones do, and one may prattle in conversation without permanent effect. Not so in writing. "To write prattle is as objectionable as to talk like a book."

Writing is more or less of an effort for most of us, and it is an effort worth while. It has in it the opportunity for growth and improvement, which is in the heart of every ambitious person. It is the opposite of routines.

How largely we judge a person, especially one in technical lines, by his writing! The range of readers usually is much wider than the range of personal acquaintance. A favorable impression may be conveyed by conversation or a verbal report, but the broader reputation and the final test for the public is what the worker publishes, the matter he commits to writing. This applies to

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the manner of presentation, as well as to the substance. People are likely to think the mode of writing reflects the mode of thinking. I have known some skillful investigators who labored under a great handicap in presenting the results of their efforts, and others who were saved only by the help of capable editors. Their appreciation of the spirit that actuates a sympathetic editor, and their patience with his criticisms and suggestions, were their salvation. So, hats off to the editor!; he is the writer's best friend.

We may think of writing as a means of visual presentation. Whether the subject be simple or intricate, the aim is to make the reader visualize what is being described. This calls for effort to put oneself in the position of the reader, to realize what he may need in order to understand, to answer his questions as he reads.

The difficulty is increased by the fact that the writer can not be aware of his audience as the speaker can,--of the impression he is making, of the reaction to the manner and substance of what he is presenting. This increases his dependence on the editor and other critics.

Take pains, therefore,--first with yourself, then with your reader. He is entitled to it, and you are entitled to be read and understood if you have something worth while to say.

Don't overestimate your ability in writing and don't underrate the job. Few who read a well-written article realize how much labor probably has been put into it. Don't be ashamed, therefore, of being particular, of working over what you have written, of striving to make it clearer, more direct, and free from superfluities. Assume a critical attitude toward every important item. See that it states what it is intended to, and that it will be understood that way by careful readers. Try to guard against being misunderstood. How often

writers say, when an item is questioned: "Oh, I didn't mean to be understood that way!"

Not all of us may possess originality; but clarity, unity, simplicity, economy of words, are virtues which all may attain.

Clarity and precision are of prime importance in telling a true story in a way that will not be misinterpreted. Words are designed to express ideas. There are shades of meaning which words are specially designed to express. Hence the importance of precision, of using the right word to express the idea or thought of the writer. This is especially true in technical writing. One writer maintains that in prose, "A thought or idea can be perfectly expressed in one way only." Whether or not we fully agree with this, a statement which begins with obscurity and ends in confusion not only mars the pleasure of reading but may become maddening.

Science is exact; it is orderly; it is definite. Writings in it ought to partake of that character. They ought to express frank, straightforward ideas or convictions, supported by facts. They ought to be honest and characterized by courage,--not to hint at things not proven or suggest vaguely things that may be given a double meaning, according as developments favor or oppose. No one who has initiative and originality can expect to be right all the time. He will express views which have to be discarded, because that is the nature of hypotheses, but he will be clear in his writing, as in his thinking, and will see no disgrace in having to abandon an idea, provided he did not overstep his facts and reasoning.

If every scientific contribution were a clear, logical presentation of the findings, with proof of each new step, how steadily we should advance and how easy it would be to follow the progress. But this calls for a high type of originality and simplicity. It seems hard for many persons to be simple,--to

present their work for just what it is, fitting it into its setting.

State facts as literally as possible; otherwise you may run the danger of being misunderstood. One striving for reputation in technical fields can not afford to make loose statements which may be misconstrued. He'll get caught up too often and will fail of being taken seriously. A writer who does not strive to make his meaning clear and unequivocal will be likely to suffer for his carelessness by being neglected or discounted.

Writers sometimes ^strive for spontaneity, having little patience with studied precision and holding the notion that to have punch a sentence must come "hot off the bat." This may be fine in some kinds of writing, but the art of writing has been defined as being deliberate while seeming to be spontaneous.

Accuracy, the truth clearly told, is far more important than literary style. If there is any conflict, clarity and directness should have the preference. But usually a straightforward style, not without literary attractiveness, is compatible with the requirements. The point is, the author should not be obsessed with the literary quality, to the exclusion of other considerations.

Restrict the scope--don't try to cover too much ground or too many things in a single article. Make it plain what is being treated, and let the account follow logically. Preserve unity, even though the article contains a number of main topics. Select the material thoughtfully, to present what is necessary to the reader's understanding without either burdening him or omitting things that are essential. This is a matter of good judgment.

Develop the main ideas or significant points as the article proceeds. Weigh the relative importance of the various topics. Expand the more important ones; give the reader credit for being able to understand the simpler ones with

a brief explanation. Try to so present your matter that your reader will not only follow passively, but will be stimulated to think. Remember that an account of a piece of scientific work is not merely designed to be read but to be studied, and then put away where it may be referred to later. It is not designed merely to report an investigation, but to stimulate as well as inform. Then others with the new vision given them may take a further step forward.

The practice of dictating to a stenographer, without having thought the article through and without proper preparation of notes and arrangement of material, is believed to be a frequent cause of poor writing. In talking, we are not so careful to economize words or to make statements exact in meaning. Most people dictate as they talk. This tends to verbose style. Once dictated, the matter is liable to be left without serious effort toward analysis and condensation. I recall a station man complaining that he couldn't sit down and dictate a bulletin full blown and ready for the printer, as he assumed others did, but he had to spend lots of time revising. I congratulated him on his recognition, not only of his limitations, but of what was necessary to clear writing, for his effort was repaid.

Revision of Manuscripts. A frequent difficulty which editors have to meet is lack of revision by the writers. Such revision is a quality of careful writers. Sir T. Clifford Allibutt said it was his custom to make four drafts of a manuscript before he considered it ready for the printer. The first was compiled from notes, to get the matter together in logical form. In the second draft he deleted redundant words, phrases, and sentences, saving considerable; he rearranged sentences out of position and added any second thoughts that came to him. In the third draft sentences and paragraphs

were recast so as to carry out his meaning and leave only one interpretation, with particular attention to the choice of exact words. A few weeks later the entire manuscript was gone over the fourth time for final additions and revisions.

Sir William Osler often was envied for the excellence of his writings. He is said to have followed a similar plan, first arranging his notes, written at opportune moments; then making a rough outline in longhand; next a first typewritten copy, which was interlineated, deleted, and transposed; then a second typewritten copy which was further polished, and finally a third copy which was sent to the printer.

Anatole France, the Nobel prize winner in literature, regarded six revisions necessary: (1) he "enlivened what was platitudinous"; (2) he "wed out the dandelions"-- the whos, whiches, and whoms; (3) he eliminated the semicolons, shortened his sentences, and struck out phrases which merely linked one sentence with another, or marked a transition from one thought to another; (4) he gave special attention to the order of sentences and repetition of the same word; (5) he "chipped away the pastry,"--all that was adventitious and redundant; and (6) he planed down his phrases to make them smooth. These revisions did not necessarily mean new drafts each time, but going over the manuscript with special objects in mind.

Such a painstaking course is all too rare among technical writers. They feel they haven't time for it, even if they appreciate its merits. But if writers like those mentioned could find time to be systematic and critically careful, surely the average writer can, and the practice is worthy of his effort.

Failure to revise carefully is responsible, not only for lack of

clarity and exactness of statement, but for long, poorly arranged, and unpruned articles. You remember the alibi of the man who put in a long, involved report: "I hadn't time to make it shorter."

The task of the editor is somewhat different from that of the one who is reporting investigations or discussing technical subjects. For the editor it is more than marking the copy for the printer, seeing that all the i's are dotted, the t's crossed, and punctuation sprinkled in where it will do the most good. The editor of technical and semipopular publications represents the reading public. He must look out not only for typographical oversights but for danger signals-- things which to his practiced eye suggest a danger of misunderstanding, of not being clearly followed, of statements being challenged for lack of proof. It is for him, therefore, to "stop, look, and listen."

Research and Writing. There seem to be quite close analogies between writing articles reporting or discussing technical matters, and the carrying on of research. There are also analogies between the critical examination or editing of a technical manuscript, and the critical scrutiny of a piece of research to see whether it is complete and safe as far as it goes.

The doing of research requires first of all a subject, which is likewise the case in writing--the choosing of a topic and a title. Then the object aimed at must be determined, along with the scope of the investigation; the effort must be a limited one, necessarily, and so it needs to be definitely directed to avoid wandering. This is emphatically the case in writing a technical paper. Next the worker must have a background, to know just where to begin his research and to supply its setting. The provision for this by looking up the subject corresponds to the introduction of the article,

which orients the reader and prepares him to be intelligent about what follows.

In research, the making of the plan, with the steps to be followed in accomplishing the objective, is of course the main feature. Similarly, in writing a technical paper, the story in which the subject is unfolded logically, step by step, is the part on which chief interest hinges. A good deal of research is necessarily of the cut-and-try order; the worker can't always go directly to the experiment or develop the idea that will meet the purpose. Likewise in writing, the author must cut and try, experiment in stating a fact or an important idea, keep at it until it will stand the test.

The next stage in research is marshaling the facts to see what has been accomplished, the selection of those that mark advance, that are significant in what they prove or what they suggest to the investigator as next steps. You will recognize this as a highly important step in writing also,-- assembling the facts or the data, making selection, arranging them to show what they prove, supporting every important statement so that the reader may form a judgment, avoiding being dogmatic.

Finally there is the critical, searching examination of the investigation and the application of tests that will strengthen confidence in its results; and in case of the technical paper the rigid revision to strengthen, safeguard, and improve.

If you concede the analogies, the two types of work call for somewhat similar traits of mind,--care, patience, and orderliness, a critical, inquiring attitude toward the work in both cases,--not the same special knowledge and constructive ability on the part of the writer as of the investigator, it's true, but similar standards for accuracy, for adequacy, striving toward perfection, as distinguished from the attitude that "anything will do." Both are exacting and painstaking types of effort.

The making of a publication is even more serious, in a way, than the making of an experiment. A publication is addressed to the public; it is permanent; it can not be erased; it stands as a lasting example of the author's standards and his efforts to live up to them--his success and his mistakes. The unsuccessful experiment, on the other hand, may never be written up and hence never known except to the very few. It is largely a negative quantity in its power to embarrass its maker. He is like the physician who buries his mistakes. To me, there is always something sobering in the thought that the printed word is permanent and is accepted as the expression of deliberation and mature judgment, as contrasted to the impulsiveness of the spoken word.

The object of an investigation is to make a contribution, to add something to the sum total of what is known, to make knowledge more secure. So it is with a written article,--it attempts to treat the subject, whether on the basis of original data or gleaned material, in a clearer, more convincing, and more final way than it ever has been before. Unless the article does this, it won't be a contribution; it may only cumber the literature and increase the burden of those who are searching it for something new or better.

From these analogies it might seem that the investigator would perforce be an ideal writer of technical articles; that, the ideals being similar, he would combine with them his intelligence about the subject so that his account would be exemplary. We might perhaps assume that success in this direction would be in a degree proportional to his success as a searcher after truth. But apparently this is not always the case. There is a lack of certain qualities,--patience with details, ability to take pains, capacity for putting himself in the reader's place. The investigator may know too much about his sub-

ject and assume too much on the part of the reader. A good investigator is not always a good teacher in elementary lines.

So there is opportunity for the technical editor to do a useful service before it is too late--before the matter is where it can not be changed. In the nature of the case there is a large amount of immature, unproductive research, as there are volumes of writing which add to neither literature nor knowledge. It is the tribute the world pays to those who are practicing. The efficient editor can temper the situation, if he has a chance.

If, then, a technical manuscript is similar to a technical project for investigation, what is the test? We may ask in each case: Is it original or confirmatory; is it instructive and informative, or is it constructive? Is it to traverse a broad subject, or relate to a concrete and limited one?

A contribution is about all that most investigators or writers can make; rarely will their products be so novel as to mark epoch-making advances. That being so, is the work or article a useful addition--one needed, or a repetition of what has been sufficiently done before? Does it represent new power or unproductive energy? Can't it be done or said a little more effectually than ever before? If it is not on a new subject, can't some originality be introduced in the treatment which will make it a real contribution? These things relate to the actuating motive.

Beyond this, are the plan and the method adequate? Is the arrangement orderly, systematic, step by step; or does it flit from one thing to another without completing anything? For the manuscript, like investigation, is progressive.

The whole underlying idea in research is to form a critical judgment about a subject, based on the showing of such data as it has been possible to

develop. So in the presentation of research, this idea of a clear, critical judgment should be reflected. The publication is the means of taking the reader along in this excursion into new fields,--in the development of an idea, the formation of a more critical judgment. Hence the reader must be given enough to enable him to follow intelligently, but not so much that he will get lost and bewildered in the jungle.

Finally the test of a piece of research or of a manuscript is whether it leads to a reasoned conclusion; The latter may not necessarily be absolute, for little of our knowledge is absolute; but, if possible, it ought to be more than a bare comparison between things, the value of none of which is stable.

Example: Lot A was fed one ration and did better than lot B, fed another; but what of it?--what does it signify in the way of a broader or more specific fact that can be accepted and held until proved otherwise? The author ought to have produced something more than an aggregation of data, to have found something that has enabled him to form some definite convictions. Otherwise he hasn't made a constructive contribution,--merely added data which may clutter the ground or at most help someone else to form a conviction.

GENERAL OUTLINE FOR A SCIENTIFIC PAPER.

1. Title.
2. Introduction--nature of the subject or the problem; review of more important literature applying immediately to the subject.
3. Objects--specifically the points to be developed in the article.
4. The plan followed in attaining these objectives--somewhat general, in order to prepare the reader to follow the several steps. Emphasize here the features that are new.

5. The environment and conditions of the work-localizing it as to time, place, special facilities and equipment.
6. The report on successive steps in the investigation; the data so recorded and summarized as to bring out those that are essential and that enabled the advance and are worth recording permanently. Special methods may be described in connection with their employment.
7. Discussion of the results and what they show, bringing the several parts together to mark the advances; interpretation in relation to work of others and to the new status of the problem.
8. Summary--a condensed account of the findings expressed in reasoned conclusions.

Taking these up in more detail:

The title should be brief but descriptive. It identifies the article and differentiates it from others; hence it should be distinctive. It prepares the reader for what he may expect, and it aids in indexing. "A suitable title, suggestive subheads, a clear summary and cogent conclusions represent the framework of a well-constructed paper." A concise, pointed title is likely to suggest clear thinking in the article.

Example: "Effect of the Comparatively Small Proportion and Frequent Lack of Correlations in the Materials Dealt with in Horticultural Experiments, on the Inadequacy of the Method of Determining the Probable Error in Such Experiments." With such a mouthful, why write an article? The whole title must be read through before getting any notion of what it is about. Simplified to bring out the important words, it might read: "Application of the Probable Error in Horticultural Experiments," the rest being explained in the text.

Take your choice between: "The Influence of Temperature and Soil Moisture

on the Chemical Composition of Wheat and Corn and Their Predisposition to Seedling Blight caused by Gibberella saubinettii" and its contraction: "Factors Influencing Predisposition to Seedling Blight in Wheat and Corn." Consider this entomological title: "White Grubs, Lachnostenra sp., and Larvae of the Weevil Root Borer, Diaprepes spengleri L. Attacking Sugar Cane in the Guanica District of Porto Rico, and Methods Practiced for Controlling Them", the article was only four pages and called for only two lines in abstracting, as "Occurrence and Control of White Grubs and Weevil Root Borer on Sugar Cane." The latter would indicate what the paper was about and leave something to be said in the abstract.

You can't tell the whole story in the title, no matter how hard you try. The text is for the very purpose of taking up details. But, on the other hand, don't reduce the title to a point where it is meaningless, like "Seedling Blight," "Feeding Experiments with Steers," "Pasture vs. Dry Lot."

Titles often begin with: "A Contribution to the Knowledge Concerning—". The subject studied. Here are six words wasted, which make the title more cumbersome so it doesn't catch the eye as readily. Without this prefix, there is little danger the reader would be misled into thinking the author was assuming to cover the whole subject.

The introduction will orient the reader, by stating the problem concretely. The object will elaborate this, and the plan will further explain and differentiate the work. The reader wants to know what the author set out to do, where he took hold of the subject, the means he employed, and what he accomplished. The worker's own part ought to be clearly identified. It is disappointing to read an article without being able to determine what specifically the author has done or what his contribution consists of. Sometimes

his work is so engulfed in discussion of the general subject that the reader is at a loss to make out what is new and what rehash.

There is no excuse for this. Sometimes there is suspicion that it was purposely done,--to make an insignificant contribution seem larger. But this motive will soon be penetrated, to the author's discredit. Unless his work is set out so it can be recognized, the chances are an author will get scant credit for making an original or new contribution.

The presentation of the data--the evidence--is a highly important part, calling for close study. The selection of material requires good judgment. Often it is difficult for the one who did the work to decide. What to leave out is frequently about as important as what to put in. Failure to recognize this is at the bottom of ponderous papers which include all the data gathered as well as the mental processes of the writer.

Data are the product of the experiments and observations made during the course of the study. They vary in permanent value. The fact that they are data does not necessarily mean they are to be preserved in print. They may have no value or interest beyond their immediate setting. They may be only steps in deriving the more significant data which need recording. If they are inconclusive, why report them at this time? If they can not be analyzed and digested, they may not be worthy of printed record. We have much recorded matter of this kind.

The data, the way they are sifted, organized, and presented, are the pith of a technical article. Pride in the abundance of data is sometimes accountable for excesses in the manuscript that need to be checked. The data published ought to justify themselves as necessary. Some restraint must be exercised; all the data are rarely necessary or justified. The reader must be

content with selections and summaries; he can not reasonably expect to have all that is essential to checking the work in detail; this would require not only the entire observations but the calculations.

Data usually are best presented in tables. A table is designed to give a picture, to visualize the results better than they could be otherwise. Hence it needs to be simplified so the impression may be gained more readily. It will need some study at best, but a skillfully constructed table can aid the reader greatly. Bring together things that are comparable; reduce them to a common denominator; if possible, avoid mixing different measures or units in the same column, e. g., pounds, quarts, dollars. And above all don't try to cover too much ground or prove too many points in a single table. Long tables are bound to be complicated. Usually they can be split up to advantage.

Lead up to a table in the text, explaining what it presents; have an appropriate, distinctive heading for it--not one three or four lines long, but sufficient to identify it and the point it covers; and having presented the data, follow with an explanation in the text of what the table is believed to show. The careful reader will judge for himself, but he is entitled to know what the author makes out of it.

To summarize: The writing of a bulletin or a technical article is a matter worthy of one's best effort. No one need apologize for being particular and painstaking, even to the point of being meticulous; for the most part we are far too easy with ourselves.

A technical paper is designed to be read, to add to knowledge and intelligence. The writer is the vehicle--not the one primarily to be benefited. Such a paper is deliberate and purposeful, as distinguished from

being hurried and directed "to whom it may concern." It implies a concrete subject, and a clear view of the field and use it is to serve. Its preparation deserves study,---analysis into parts, careful weighing and arranging of these, selection of the material needed to serve the purpose, with courage to eliminate what is superfluous; and concentration to avoid wandering.

The writing of such an article calls for a sympathetic attitude toward the reader---the one for whom it is designed. He needs to be kept in mind from start to finish. This means maintaining a critical attitude toward every paragraph, to insure it means what it says and will be understood without too much study. And in the end the manuscript needs revision, with reconsideration after it is cold. Only the genius can sit down with his notebooks and dictate a satisfactory finished article; and such people are too rare to be taken as examples.

